almost simultaneous are, for the purposes of the clinician, the same as those in which heart arrest precedes respiratory paralysis. Finally, the general results of our new experiments also coincide with our previous experience in the laboratory, and with what we believe to be the general belief of physiologists—that cardiac arrest is specially prone to occur when chloroform is administered rapidly and in a concentrated form."

8. It will probably serve a useful purpose, seeing that the points on which we disagree with the Hyderabad Commission have been set forth in some detail above, if we now state in a summary form the more important matters on which we are agreed.

(I) We are agreed that death from chloroform occurs by failure of respiration, and that this is probably the most frequent mode of death.

(II) We are agreed that chloroform causes a gradual fall in the blood pressure as registered by kymographic tracings from the carotid artery. This is the normal effect of chloroform.

(III) We are agreed that when chloroform is pushed this gradual fall may be so great as to become in itself "dangerous." This is admitted in Paragraph (8) of the Hyderabad Report, where they state that after an animal has been involuntarily holding its breath "the gasping respiration which succeeds then causes very rapid inhalation of chloroform, with immediate insensibility and a rapid fall of blood pressure, *which quickly becomes dangerous.*" (The italics are ours.)

(IV) In addition to this, which we may call the normal effect of chloroform on the heart and blood pressure, both of us observed peculiarly sudden and unexpected falls of pressure, with slowing of the heart. We are agreed that this phenomenon occurs, and the Hyderabad tracings show that it is frequent. We differ as to the cause of its occurrence, the Hyderabad Commission ascribing it to asphyxia, while we contend that neither in the time of its occurrence after holding the breath nor in its general characters does it correspond with the fall of pressure due to asphyxia. Whatever be the explanation, the occurrence is in itself sufficiently serious, and should not be minimised as forming one of the sources of danger in the administration of chloroform.

THE CROONIAN LECTURES

ON

CEREBRAL LOCALISATION.

Delivered before the Royal College of Physicians of London.

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Lecture II.

Mr. President and Gentlemen,—I will now invite your attention to a brief consideration of the phenomena of electrical irritation of the brain of the monkey, more especially as determined by my own experiments, and those of Horsley, Schäfer and Beevor, which, though in all essentials confirming mine, have been worked out with more elaborate detail and minuteness.[1]

Beginning anteriorly we find that what is generally termed the prefrontal lobe—that is, all in advance of a line drawn at right angles to the anterior extremity of the precentral sulcus—gives no, or very doubtful, response to electrical stimulation.

Between this line and that of the precentral sulcus continued upwards to the longitudinal fissure, there is a region or area (1, 2, Fig. 5; Figs. 6 and 7, head), stimulation of which causes opening of the eyes, dilatation of the pupils, and movements of the head and eyes to the opposite side. This area has been further differentiated by Beevor and Horsley, according to the primary movements which result from minimal stimulation of the points indicated on their diagram (Fig. 8). The corresponding region in the brain of the dog is (12, Fig. 9). No similarly differentiated centre is seen in the cat (Fig. 10) or rabbit (Fig. 11).

At the upper extremity of the central convolutions (ascending frontal, ascending parietal, and postero-parietal lobule) (1, 2, Fig. 5; leg Figs. 6 and 7), and extending over the margin of the hemisphere into the posterior part of the marginal convolution, or paracentral lobule, electrical stimulation causes movements of the *lower extremity.* The movements vary according to the position of the electrodes on this area. Behind the fissure of Rolando the movements are chiefly, or exclusively, of the foot or toes. Anterior to the fissure of Rolando they are combined with flexion of the leg and thigh. With minimal stimulation the movements may be still further differentiated (Fig. 8), and, in particular, the great toe can be excited to movement separately by stimulation at the upper extremity of the fissure of Rolando. The corresponding region in the brain of the dog, cat, and rabbit, is indicated by 1, Figs. 9, 10, 11.

Below the leg area, and partly in front of it, and occupying the middle third, or rather two-fourths of the central convolutions, there is a region stimulation of which causes movements of the upper extremity (3, 4, 5, 6, *a*, *b*, *c*, *d*, Fig. 5, and arm, Fig. 6). In this area it is possible to differentiate, more or less completely, movements of the upper arm (protraction and retraction); movements of the forearm (flexion, supination, etc.); and of the wrist, fingers and thumb. The proximal movements are represented most in the upper part of this region; the distal movements, that is, those of the fingers and thumb, most at the lower part.

By minimal stimulation at the lower extremity of the intraparietal sulcus the thumb may be individually thrown into the action (Fig. 8). The corresponding region in the brain of the dog is that indicated by the numerals 4 and 5 situated on the postcrucial division of the sigmoid gyrus (Fig. 9), and by the same numerals on the brain of the cat (Fig. 10), together with *a* situated on the anterior extremity of the second external convolution. Stimulation of this latter point causes protrusion of the claws; an action comparable to the movements of the wrist and fingers excited from the lower part of the ascending parietal convolution in the monkey. The corresponding region in the brain of the rabbit is indicated by the same numerals (4, 5, Fig. 11).

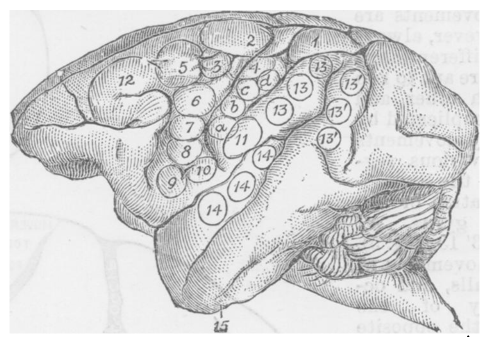

Fig. 5.—The left hemisphere of the monkey. 1. The opposite hind limb is advanced as in walking; 2, flexion with outward rotation of the thigh, rotation inwards of the leg, with flexion of the toes; 3, the tail; 4, the opposite arm is adducted, extended, and retracted, the hand pronated; 5, extension forwards of the opposite arm; *a*, *b*, *c*, *d*, movements of fingers and wrist; 6, flexion and supination of the forearm; 7, retraction and elevation of the angle of the mouth; 8, elevation of the ala of the nose and upper lip; 9 and 10, opening of the mouth, with protrusion (9) and retraction (10) of the tongue; 11, retraction of the angle of the mouth; 12, the eyes open widely, the pupils dilate, and head and eyes turn to the opposite side; 13 and 13', the eyes move to the opposite side; 14, pricking of the opposite ear, head and eyes turn to the opposite side, pupils dilate widely.

Below the arm area, and occupying the lower third of the central convolutions, there is a region stimulation of which causes movements of the face, mouth and tongue. In the upper part of this area can be differentiated centres for movements of the upper facial muscles (7, 8, Fig. 5) in front of, and platysma (11) behind the fissure of Rolando. The corresponding region in the brain of the dog, relatively much larger than in the monkey, is indicated by the numerals (7, 8, Fig. 9), and the same indicate the homologous regions in the brain of the cat (Fig. 10), and rabbit (Fig. 11). In the lower portion excitation causes movements of the mouth and tongue; protrusion of the tongue being generally caused by stimulation anteriorly (9, Fig. 5), and retraction by stimulation posteriorly (10, Fig. 5).

It has further been demonstrated by Semon and Horsley[2] that excitation of the lower extremity of the ascending frontal convolution causes phonatory closure of the vocal cords. The phonatory closure of the vocal cords was first demonstrated ocularly in the dog, on irritation of the pre-sigmoid region, by Krause,[3] though I

[1] Horsley and Schäfer, *Phil. Trans.*, B. 20, 1888; Beevor and Horsley, *Phil. Trans.*, B. 1890.

[2] On the Central Motor Innervation of the Larynx, Journal, December 21st, 1889.

[3] *Pflüger's Archiv.*, 1883.

had many years previously,[4] given audible demonstration of the same fact by showing that stimulation in this neighbourhood not infrequently caused barking; and similar effects (spitting, mewing) by stimulation of the homologous region in the brain of the cat. I also pointed out that the movements occurring on stimulation of this part were distinctly bilateral, an effect which Krause, Horsley, and Semon, have found to be true also of movements of the vocal cords.

The areas for the head and eyes, arm and leg, extend over the margin of the hemisphere into the mesial aspect or marginal convolution. These I had to some extent noted in my first experiments, but a more thorough exploration of the reactions of this region was first made by Horsley and Schäfer.[5] Excitation of this convolution from before backwards (see Fig. 7), causes movements of the spine, tail, and pelvis; behind these, extension of the hip, flexion of the leg, and lastly, movements of the foot and toes. These movements are not, however, always clearly differentiated, as they are apt to run into each other, and to be complicated by secondary movements of the various segments of the limb.

Stimulation of the angular gyrus, *pli courbe* (13′ 13, Fig. 5), causes movements of the eyeballs, and occasionally of the head, to the opposite side, generally combined with an upward or downward direction, according as the electrodes are on the anterior or posterior limb of this gyrus. The condition of the pupils is not constant, occasionally they are contracted. The corresponding region in the brain of the dog is indicated by 13 (Fig. 9), situated on the second external convolution, and the homologous region in the brain of the cat (Fig. 10), and the rabbit (Fig. 11), is indicated by the same numerals.

Excitation of the occipital lobe appeared in my earlier experiment to yield negative results. But Luciani and Tamburini[6] occasionally obtained movements of the eyeballs similar to those occurring on excitation of the angular gyrus, though less marked. And Schäfer[7] describes similar movements as occurring from stimulation of different parts of the occipital lobe and neighbouring regions. My own experiments on several monkeys, though not opposed to those of Schäfer, are more in harmony with those of Luciani and Tamburini, and show that, though movements of the eyeballs may be obtained by excitation of the occipital lobe, they are, as a rule, less constant and less easily excited than from stimulation of the angular gyrus.

Stimulation of the superior temporal gyrus (14, Fig. 5) causes pricking of the opposite ear, opening of the eyes, dilatation of the pupils, and direction of the head and eyes to the opposite side. Precisely the same reaction occurs after stimulation of the posterior limb of the third external convolution of the brain of the dog (14, Fig. 9), and so also in the brain of the cat (Fig. 10), and homologous region of the brain of the rabbit (Fig. 11). Sometimes only movements of the ear are caused, and sometimes the animal attempts to bound off the table as if suddenly startled.

Stimulation of the hippocampal lobule or anterior extremity of the hippocampal gyrus in monkeys, dogs, cats, and rabbits causes precisely the same results—namely, torsion of the nostril on the same side—as if from irritation applied directly to the nostril itself. Irritation of the gyrus hippocampi occasionally caused movements such as might be conditioned by direct irritation of the opposite limbs; but beyond this I have not been able to obtain any constant reaction from stimulation of the rest of the temporal lobe or other portions of the cortex.

Such is briefly a summary of the phenomena of electrical irritation of the different regions of the cerebral cortex. These results, apart from the interpretation which we put upon them, indicate some form of functional differentiation; and it is obvious, on comparing the corresponding areas in the brain of the monkey, dog, cat, and rabbit, that there are great differences as regards their relative extent, and the character of the movements with which they are in relation. Whether complete parallelism obtains

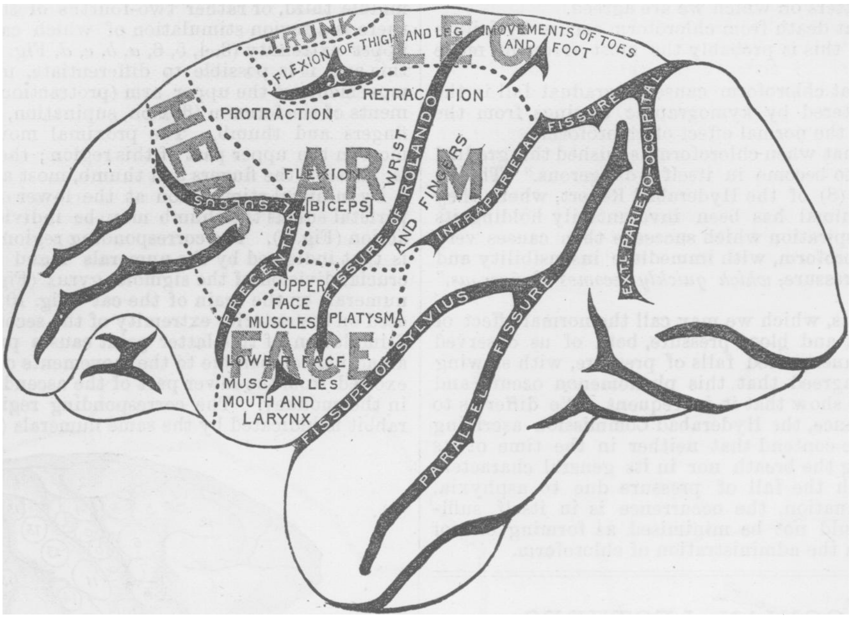

Fig. 6.

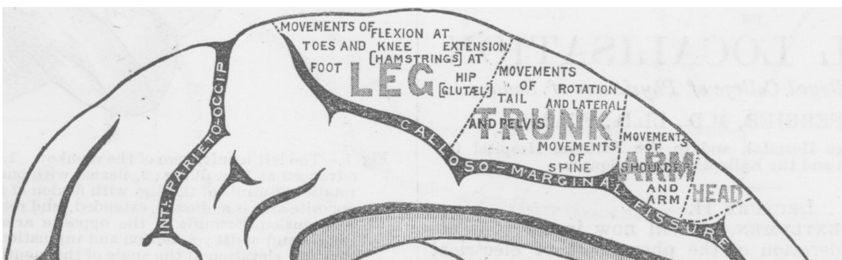

Fig. 7.—The motor areas according to Horsley and Schäfer.

4 *West Riding Asylum Reports*, 1873.
5 *Phil. Trans.*, vol. 179, 1888.
6 *Sui Centri Psico-Sensori Corticali*, 1879.
7 *Proc. Roy. Soc.*, 1888.

between the brain of the monkey and the brain of man is a question which, until recently, could only be answered by reference to the facts of localised lesions. Bartholow[8] and Sciamanna[9] had observed movements of the opposite side of the body on stimulation of the cortex through the dura mater—the former in a case of cancerous ulceration and the latter in a case of trephining. But their results, though so far in accordance with those of experimentation on monkeys, were lacking in precision. Recently, however, surgeons have on several occasions resorted to gentle faradisation of the cortex, in order to define accurately the regions which they have desired to extirpate for the cure of focal epilepsy. One of these has been reported by Horsley, and several others have been quoted by Mills in his valuable memoir on Cerebral Localisation in its Practical Relations.[10] In one case the lower halves of the two central convolutions—the posterior extremity of the second frontal and the posterior superior corner of the third frontal convolution—were exposed in the left hemisphere. "Careful examinations were made with the faradic current applied to the cortex with the view of locating the proper centres for excision. Four distinct responses in the shape of definite movements were obtained after several trials; these were (1) in the most anterior position at which movements resulted, distinct conjugate deviation of the head to the opposite side; (2) a little below and behind this point, drawing of the mouth outwards and upwards; (3) above this spot for movements of the angle of the mouth, about half an inch, extension of the wrist and fingers was produced; (4) behind and above the latter point, distinct flexion of the fingers and wrist. Continuing and increasing the faradic application at this last determined point, the fingers, thumb, wrist, and forearm were successively flexed, and the whole extremity assumed the 'wing-like' position. The order of events, according to three persons who were present, and who observed the patient's spasms, being exactly that which had been noticed at the beginning of his convulsive seizures."

In a second case reported by Keen:[11] "On touching the cortex with the electrodes at a position which apparently corresponded to the anterior portion of the pre-Rolandic convolution, just behind the precentral fissure, movements of the wrist and fingers were produced. The hand moved in extension in the mid-line and to the ulnar side at different touches, the fingers being extended and separated. Above the region in which these movements were obtained application of the current caused movement of the left elbow, both flexion and extension, and of the shoulder, which was raised and abducted. Below the region, where the hand movements were excited, the application of the current produced an upward movement of the whole of the left face." These results correspond very closely with the position of the various centres as already defined.

In another case, reported by Lloyd and Deaver,[12] an area was exposed in the right hemisphere corresponding to the junction of the middle and lower thirds of the central convolutions. When the electrodes were applied to a point just posterior to the fissure of Rolando the movements which occurred were in order—flexion of the thumb on the palm, flexion of the fingers, flexion of the wrist, extending to flexion of the elbow. At a point in front and below stimulation caused contraction of the facial muscles of the opposite side.

In a fourth case, reported by Nancrede,[13] movements of the thumb were induced by stimulation of a region corresponding to the second lower fourth of the ascending parietal convolution. All these results are in close harmony with those obtained on stimulation of the cortex of the brain of the monkey, and we have therefore every reason to believe that, *cæteris paribus*, the functional relations of the human cortex are identical with those of the lower animals.

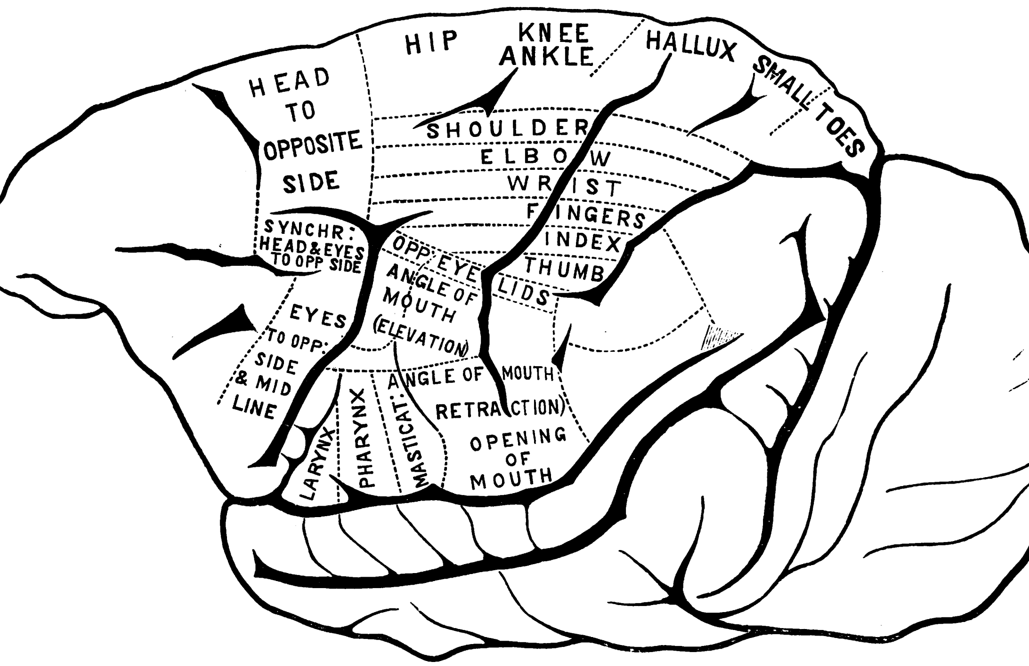

Fig. 8.—Motor areas according to Beevor and Horsley.

So far as the excitation method is concerned, we are entitled to say that, whether the individual segments of a limb are separately localised, or are represented, more or less, throughout a common area, the areas as a whole are completely differentiated from each other. No movements of the leg result from irritation of the facial centres, nor of the face from the leg centres. The face area and leg area are thus entirely differentiated from each other, and from the oculo-motor area. What is true of centres widely apart is doubtless true of centres which are in close proximity to each other. The fact that stimulation of the margin of a given area is apt to produce joint movements of this and the adjoining area must not be taken to imply that this portion subserves conjoint functions—say of the arm and leg, or arm and face.

The true explanation appears to me to be that the excitation method is unable completely to differentiate the boundaries of the respective centres. Regions which are in the closest proximity to each other, anatomically and functionally, are apt to be discharged together by diffusion of the stimulus. Nor, even if we are unable to entirely dissociate the centres from each other by the destructive method, are we on this ground entitled to conclude that there

[8] *Amer. Journ. Med. Sciences*, April, 1874.
[9] *Arch. di Psichiatria*, 1882.
[10] Read before the Washington Congress, September 19th, 1888; reprinted in *Brain*, 1889.
[11] *Amer. Journ. Med. Sciences*, November, 1888.
[12] *Amer. Journ. Med. Sciences*, November, 1888.
[13] *Medical News*, November 24th, 1888.

is any functional fusion between the two; for a destructive lesion, however small, situated on the margin of any given centre, is calculated to affect the functions of more than one. Facts will be adduced as we proceed which to my mind justify the conclusion that the areas as a whole are as completely differentiated from each other as the limbs themselves, or one organ of sense from another.

We have seen, however, in respect to the individual movements of a limb, that though one particular movement can frequently be isolated by minimal stimulation of a definite point within the general area, yet the same movement may occur along with others when another part of the area is under stimulation. This may be interpreted either on the supposition that the particular movement, say of the thumb, is represented throughout the whole of the arm area, or that it is only a case of diffusion of the stimulus from one part to another. It is difficult to decide which of these views is the correct one, and it may be that neither accurately represents the whole truth. For the reactions of the limbs which result from stimulation of the cortex are not mere muscular contractions, but synergic movements co-ordinated into acts; and inasmuch as has been shown by Professor Yeo and myself,[14] the same muscles or muscular groups enter into the composition of the different movements innervated by the respective motor roots of the brachial and crural plexuses, so the same muscular groups may have a multiple representation in the various sub-

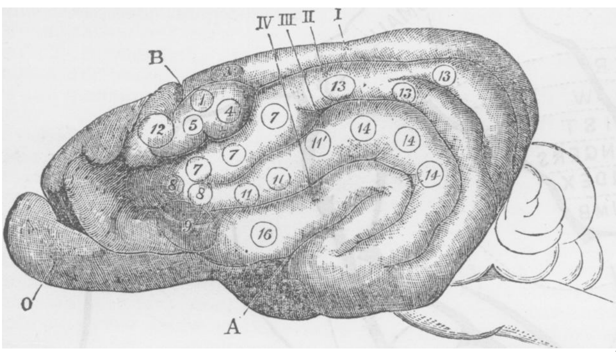

Fig. 9.—Left hemisphere of the brain of dog. 1. The opposite limb is advanced; 3, lateral or wagging motion of the tail; 4, retraction with adduction of the opposite fore limb; 5, elevation of shoulder, and extension forwards of the opposite fore limb; +, flexion of the paw; 7, action of the orbicularis oculi and zygomatics; 8, retraction and elevation of the opposite angle of the mouth; 9, opening of the mouth and movements of the tongue; 11, retraction of the angle of the mouth; 12, the eyes widely opened with dilatation of the pupils, with movement of the eyeballs and head to the opposite side; 13, movement of the eyeballs to the opposite side; 14, pricking, or sudden retraction, of the opposite ear; 15, torsion of the nostril on the same side.

divisions of the general area. And it would appear that in the cortical areas there is a much greater differentiation than in the respective segments of the brachial and crural enlargements of the spinal cord. But in my opinion any further multiple representation outside the general area of a limb is altogether opposed to the facts of localisation as determined either by the methods of excitation, or destruction, or both.

We have next to inquire into the important and much disputed question as to the signification of the motor reactions which result from electrical stimulation of the different cortical regions. Though many of the movements are evidently such as may be termed purposive, it does not follow that they are indicative of direct stimulation of motor regions in the strict sense of the term, for the movements may be the result of some psychical condition incapable of being expressed in physiological terms; or they may be reflex, and thereby not differing essentially from those resulting from peripheral stimulation; or they may be motor in the sense of being due to irritation of parts in direct connection with the motor tracts and motor nerves, or they may be partly one and partly the other. The method of excitation itself is not competent to solve these questions, and requires as a complement the strictly localised destruction of those areas, stimulation of which gives rise to definite motor reactions.

A careful consideration of the reactions in different orders of animals, and the fact that similar movements are in some cases

[14] *Proc. Roy. Soc.*, 1881, The Functional Relations of the Motor Roots of the Brachial and Lumbo-sacral Plexuses.

excitable from different cortical regions, led me to believe that they might have various significations, and I formed the hypothesis that some might be due to stimulation of motor regions proper, while others might be looked upon as the associated expression of subjective sensation. On this hypothesis I instituted localised destructive experiments, and thus determined the existence of sensory or perceptive centres respectively related to the different forms of sensibility, as well as of centres more especially, if not exclusively, motor in character. The existence of distinct sensory centres has been confirmed by succeeding physiological and clinical research, and I have the satisfaction of thinking that such errors as I have committed in the delimitation of the various sensory regions have been errors more of omission than of commission, and that the localities in which I originally fixed the respective sensory areas correspond in part at least with the position assigned to them by the most reliable experimental and clinical methods.

The Visual Centres.—I will first call your attention to the reactions occurring on stimulation of the occipito-angular region in monkeys, and its homologue in the lower orders of animals. The reactions, as we have already seen, are movements of the eyeballs, and occasionally of the head to the opposite side; and frequently also of the pupils, not always uniform in character, being sometimes contraction, at other times dilatation. These movements I have found to be most easily and most uniformly excited from the anterior and posterior limbs of the angular gyrus. As a rule, along with the lateral movements there is upward direction when

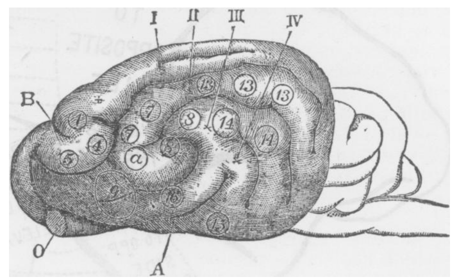

Fig. 10.—Left hemisphere of the brain of the cat. 1. Advance of the opposite hind limb; 4, retraction and adduction of the opposite foreleg; 5, elevation of the shoulder, with flexion of the forearm end paw; A, clutching or grasping action of the paw, with protrusion of the claws; 7, elevation of the angle of the mouth and cheek, with closure of the eye; 8, retraction, with some degree of elevation of the angle of the mouth, and drawing downward and forward of the ear; 9, opening of the mouth and movements of the tongue; 13, the eyeballs move to the opposite side; 14, pricking of the ear, and head and eyes turn to the opposite side; 15, elevation of the lip and torsion of the nostril on the same side; divergence of the lips.

the anterior limb, and downward when the posterior limb of this gyrus is excited. Movements of the eyeballs are also obtainable, as Luciani and Tamburini first pointed out, from irritation of the occipital lobe. Schäfer, who omits the anterior limb of the angular gyrus, though I have found this as excitable as the rest, obtains downward movements of the eyes on stimulation, not only of the posterior limb of the angular gyrus, but also of the upper end of the middle temporal gyrus, that part of the occipital lobe immediately behind the external parieto-occipital fissure, and on each side of the internal parieto-occipital fissure. He obtains upward movements on stimulation of the under surface of the occipital lobe, the lower part of the mesial aspect of this lobe, and of the lower margin of the convex surface. He obtains a simple lateral movement of the eyes on excitation of the rest of the convex aspect of the occipital lobe and a narrow strip of the mesial surface along the margin of the great longitudinal fissure. The middle portion of the mesial surface does not appear to be included in this scheme.

My hypothesis that these movements of the head and eyes are the signs of the arousal of subjective visual sensation, and due to associated action of the frontal or subcortical oculo-motor centres, has received confirmation from the experiments of Schäfer on the latency periods of the ocular movements following excitation of the frontal and occipito-temporal regions respectively.[15] The result of this comparison made in a number of monkeys was to show that the latent period is longer by some hundredths of a second in the case of stimulation of the occipital lobe than of the oculo-motor centre of the frontal area; thus indicating that in

[15] *Proc. Roy. Soc.*, February 13th, 1888.

the former case the nervous impulses must be transmitted through at least one more nerve centre than in the latter. This would agree with the hypothesis that in the one case the movements were reflex, and in the other direct. The fact that the ocular movements are still obtainable on stimulation of the occipito-angular region, after complete removal of the frontal regions, shows that they are not necessarily indicative of the associated action of these cortical centres, but may be due, if they are not always so, to excitation of the oculo-motor centres of the corpora quadrigemina.

Danillo[16] has found that severance of the fibres of association between the occipital lobe and the frontal region does not prevent the occurrence of the ocular movements; while Bechterew[17] and Munk[18] have found that the movements are entirely annihilated by severance of the subjacent medullary fibres. It is contended by Danillo and Bechterew that the movements cannot, therefore, be regarded as indicative of subjective visual sensation; but this would not be disproved even if the movements still continued after removal of the grey matter, for the excitation of the medullary fibres would be equivalent to excitation of the cortex itself. We may assume with Munk that there are radial or centrifugal fibres between the occipital cortex and the oculo-motor centres; and that excitation of the central expansion of these tracts would produce practically the same effect as stimulation of the centres with which they are in relation.

The occipito-angular region is the visual area of the cortex. Complete destruction of this area in the one hemisphere causes permanent hemianopia to the opposite side by paralysis of the corresponding halves of both retinæ; while bilateral destruction causes complete and enduring blindness of both eyes. Apart from the loss of vision, there are no other sensory or motor defects. The sensibility of the eyeball is intact, and the ocular movements are absolutely unimpaired. There is no impairment of the sensibility or motor power of the limbs. The other special senses are unaffected. If the destruction of the occipito-angular region is incomplete, unilaterally or bilaterally, the resulting hemianopia in the one case is not enduring, nor is the blindness permanent in the other.

There is, however, scarcely a particular of the above general statement which has not been controverted; but I am of opinion that every one of them is in accordance with the evidence furnished by strictly localised and carefully observed lesions of this region.

In my earlier investigation, I was led to believe that the angular gyri alone constituted the visual centres, a conclusion which I founded on the positive effects of lesions of the angular gyri and the uniformly negative results of destruction of both occipital lobes, except when the lesions trenched on the parieto-occipital fissure. In the latter case it appeared to me that the imperfections of vision or occasional total blindness were due to interference with the functions or the connections of the angular gyri themselves. I show you here a photograph of the brain of one of my earlier experimental animals.[19] Both occipital lobes were removed at the same time. Some encephalitis ensued, which caused extension of the primary lesions. You will see that on the right side, not only the whole occipital lobe, but also part of the posterior limb of the angular gyrus has been removed. On the left side the angular gyrus is intact, superficially, but the medullary fibres of the cut surface bulge considerably, owing to inflammatory hernia. Notwithstanding this extensive bilateral lesion, the animal, within an hour of the operation, gave clear evidence of the retention of vision; for it made grimaces, and ran away when threatened. Subsequent examination revealed the fact that vision, though good, was impaired, as indicated by some want of precision in laying hold of objects offered it. But, beyond this slight defect in vision, there was no impairment of the animal's faculties in other respects, and it continued well until its death after a second operation three weeks subsequently, in which the greater part of both frontal lobes were removed. This second operation caused no further impairment of the animal's vision—a fact of great importance in reference to the question of the relation of the frontal lobes to the sense of sight.

Inasmuch as in this animal, as well as in others, in which similar symptoms occurred, the lesions implicated the region of the parieto-occipital fissure and angular gyrus, I attributed the impairment of vision to this cause; for, when the line of section of the occipital lobes was well separated from this fissure, no impairment of vision was perceptible. Thus the occipital lobes were exposed on both sides in a monkey, and the surface destroyed by the cautery, which was also passed deeply into the interior of the lobes so as to break up the medullary fibres. The operation was completed at 3 30 P.M. The following are the notes of the animal's condition:—

"4.10 P.M. The animal, after lying in a state of stupor till now, begins to move, but staggers a good deal. The eyes are open and the pupils dilated. It indicated consciousness by turning its head when called to.

"5.45 P.M. Gives emphatic evidence of sight. Ran away when I approached it, carefully avoiding obstacles. Seeing its cage door open, it entered and mounted on its perch, carefully avoiding the cat which had taken up its quarters there. Tried to escape my hand when I offered to lay hold of it, but picked up a raisin which I had left on the perch."[20]

Notwithstanding the extensive destruction of both occipital lobes in this case, the animal, in a little more than two hours after the operation, gave the most emphatic evidence of precise vision.

In another case in which the occipital lobes were severed by a perpendicular section a quarter of an inch posterior to the parieto-occipital fissure,[21] the animal, notwithstanding the removal of at least two-thirds of both occipital lobes, gave clear evidence of vision within half an hour after the operation. In another monkey in which my colleague, Professor G. F. Yeo, removed about two-thirds of both occipital lobes, the animal within two hours after the operation was able to pick up minute objects lying on the floor.[22]

I show you here also a photograph of the brain of a monkey in which the left occipital lobe was removed by an incision immediately posterior to the parieto-occipital fissure. In this case, owing to the dressings having been torn off, the wound became septic and the animal died on the fifth day. On the day after the operation, however, no imperfection of vision could be discovered; for the animal took things offered it on the right or left front, and was able to run about the laboratory in every direction, passing among chairs and other articles of furniture without ever once knocking its head on one side or the other—actions which were altogether inconsistent with the existence of hemianopia.

You will see that the margin of the plane of section, which bulges considerably from hernial protrusion, corresponds nearly with the external parieto-occipital fissure.[23] These experiments illustrate the negative effects of unilateral and bilateral lesions of the occipital lobe. I had found, however, in my earlier experiments that destructive lesions of the cortex of the angular gyrus on the one side caused temporary complete loss of vision in the opposite eye, so that the animal responded to no test of vision, and, when urged to move, ran blindly against every obstacle in its path,[24] and that, when both angular gyri were similarly destroyed, complete blindness ensued in both eyes.[25]

The following observations were made on a monkey whose angular gyri were destroyed on both sides with the galvano-cautery. It was at once let loose, but appeared scared, and would not stir from its place. It was therefore for some hours impossible to obtain any satisfactory information as to its powers of vision. The pupils were contractile to light, and a light flashed in the eyes caused some wincing. When a piece of apple was dropped near it, so as to come in contact with its hand, it took it up, smelt it, and ate it with signs of satisfaction. Hearing was acute, and it turned its head and replied when called to by name. With the exception of reluctance to move from its position, arising evidently from a sense of insecurity, there was nothing to indicate decisively that the animal was blind. But I had found that this animal was very fond of sweet tea, and would run anywhere after it. I therefore brought a cup of sweet tea, and placed it to its lips, when it drank eagerly. The cup was then withdrawn and placed in front of it, a little distance, but the animal, though from its gestures intensely eager to drink further, was unable to find

16 *Archives de Neurologie*, vol. xviii, 1889, p. 145.
17 *Neurolog. Centralblatt.*, September 15th, 1889.
18 *Sitzungsberichte der Akad. d. Wiss. zu Berlin V.*, January 16th, 1890.
19 Experiment XXIV, *Phil. Trans.*, vol. clxv, part 2, 1875.
20 Experiment XXII, *Phil. Trans.*, vol. clxv, part 2, p. 25.
21 Experiment XXIII, *Phil. Trans.*, *sup. cit.*
22 Experiment IX, *Phil. Trans.*, 1884.
23 See Fig. 1, Plate 20, *Phil. Trans.*, part 11, 1884.
24 See Experiments VII, VIII, IX, *Phil. Trans.*, vol. clxv, 1875.
25 Experiment X, *op. cit.*

the cup, though its eyes were looking straight into it. This test was repeated several times, and with exactly the same result. At last, on the cup being placed to its lips, it plunged its head in, and continued to drink till every drop was exhausted, while the cup was lowered and drawn half way across the room. Next day the animal still continued blind, and paid no attention to threats, grimaces, or other means of appeal to its sense of vision. It was then killed, in order that the position and extent of the lesions might be accurately determined before secondary inflammatory processes could have advanced. These had already begun, but were confined to the angular gyri, which were somewhat swollen and raised, and to the adjoining anterior margin of the occipital lobes, and with slight implication of the posterior margin of the left ascending parietal convolution. The destruction was purely cortical, the grey matter alone being disorganised, and on the angular gyri exclusively.

These facts seemed to me to justify the opinion that the angular gyri were the visual centres, each being in relation with the whole of the opposite eye, since the effect of unilateral extirpation was for the time total blindness of the opposite eye, and not hemiopia. And it further seemed as if the rapid recovery from unilateral lesion were due to the compensatory action of the other gyrus; inasmuch as bilateral destruction caused total blindness in both eyes of a more enduring, and, as I ventured to suppose, probably permanent, nature. But further investigation on animals kept alive for much longer periods than were compatible with the exact limitation of the lesion under old surgical methods showed that this conclusion was erroneous. My later investigations, in conjunction with Professor Yeo, under strictly antiseptic precautions, proved that the results of unilateral and bilateral extirpation of the angular gyrus, though entirely in harmony with my previous researches, were more temporary than I had previously found, and that bilateral destruction did not cause permanent total loss of vision.[26] In illustration I would quote the details of the following experiments.

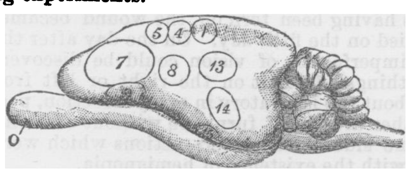

Fig. 11.—Left hemisphere of the brain of rabbit. 1. Advance of the opposite hind leg; 4, retraction with adduction of the opposite fore limb; 5, elevation of the shoulder and extension forward of the fore limb; 7, retraction and elevation of the angle of the mouth; 8, closure of the opposite eye; 9, opening of the mouth, with movements of the tongue; 13, forward movement of the opposite eye, occasionally turning of the head to the opposite side; 14, sudden retraction and elevation or pricking of the opposite ear; 15, torsion or closure of the nostril.

In one animal the left angular gyrus was cauterised with the galvano-cautery. "The left eye was secured, and the animal allowed to recover from stupor. At the end of half an hour it was evidently wide awake, but would not move unless touched. At this time it was removed from its cage and placed on the floor, whereupon it began to grope about in a sprawling manner, knocking its head against every obstacle. After some minutes of this behaviour it subsided, and refused to move. It made no sign of fear at threatening gestures, and did not wink at a thrust of the finger at its eye until the finger almost touched the conjunctiva, when the usual reflex closure occurred. Half an hour later the same tests were employed, with precisely the same indications of total loss of vision. At the end of still another half hour, while it was lying quietly in its cage, it was gently laid hold of without noise to attract its attention, whereupon it bounded away with an expression of fear and surprise, and ran full tilt against the leg of the table, where it remained groping and sprawling for a few minutes. It then started off, and this time ran against the wall, against which it sprawled helplessly. Similar things were repeated. It gave no sign of perception when it was cautiously approached without noise; but when a slight noise was made with the lips quite close to it, it darted off and came against the wall as before, where it lay down. Half an hour later, while it was resting quietly in a corner with its eyes open, the light of a lantern was flashed in its eyes, but it gave no sign. Creeping up to it cautiously without exciting its attention the observer made a slight whisper close to its face, whereupon it peered eagerly, but evidently remembering the results of running away it crouched down and would not move. Half an hour later, when it was quiet in its cage, it started suddenly on being touched, and ran its head into a corner, where it crouched.

"Next day, its left eye being still closed, it showed unmistakably the possession of vision with the right eye. It laid hold of things as usual, and ran about the laboratory in every direction, passing obstacles right and left with perfect precision, and ducking its head to pass underneath bars as it ran along the top of the waterpipes of the laboratory. No defect of vision, amblyopic or hemiopic, could be detected."[27]

In another animal, the left angular gyrus was cauterised up to the parieto-occipital fissure, the posterior part of the corpus callosum being also divided at the same time.[28]

"The left eye was securely closed, and the animals allowed to recover from its narcotic stupor. In half an hour it began to move about spontaneously, although rather unsteadily. An hour and a half after the operation it walked about the laboratory, knocking its head against legs of chairs and other obstacles in its path. When a piece of apple was held under its nose it grabbed it and ate. It continued to walk about here and there, every now and then coming to a dead halt full tilt against the wall. Three hours after the operation it again, in running about the laboratory, came full tilt with its snout against the wall, where it rested. While it was resting quietly we crept up to it; but the animal, though with eyes wide open and looking towards us, made no sign of perception. Threatening grimaces were likewise without effect; but on making a noise with our lips the animal seemed alarmed, peered forwards, and yet, though it came close to our faces, seemed to see nothing. It was tried to right and left in the same way, but there was no sign of vision to one side or the other. Next day, the left eye being still closed, the animal ran about in every direction, ducking under bars, passing objects right and left with the utmost precision, and never once knocking against anything one side or the other. Not the slightest impairment of vision could be detected, and it was able to pick up the minutest objects lying about its cage or thrown down near it."

It was first shown by Munk[29] that the permanent effect of complete unilateral extirpation of the visual sphere was not complete blindness of the opposite eye, but homonymous hemianopia, from paralysis of the corresponding sides of both retinæ. This effect he obtained by section in the line of the parieto-occipital fissure, and he localised the visual sphere exclusively in the occipital lobe, regarding the angular gyrus as the "sensory sphere" of the eye. Owing, however, to the fact, as he himself admits, that secondary inflammation and extension of the primary lesion generally, if not universally, followed his operative procedure, Munk's experiments cannot be relied upon when it is a question of the exact delimitation of any given area. It is a reasonable supposition that Munk's operations for removal of the occipital lobe would be the cause of secondary implication of the angular gyrus or its connections. The question as to the exact delimitation of the visual sphere, whether it is confined only to the occipital lobe, according to Munk, or embraces also the angular gyrus, according to my view, and the respective relations of the angular gyrus and occipital lobe to the eyes has been the subject of investigation by numerous physiologists: Luciani and Tamburini,[30] Luciani,[31] Horsley and Schäfer,[32] Sanger-Brown, and Schäfer,[33] Lannegrace,[34] Gilman Thompson and Sanger-Brown,[35] and is still a matter on which opinions are far from being in accordance.

Luciani and Tamburini, and Luciani have arrived at the conclusion that the visual centres are not confined to the occipital lobes, but embrace also the angular gyri, though the former believed that the effects of unilateral destruction of the angular gyrus were hemiopic rather than amblyopic. The experiments of Horsley and Schäfer and of Sanger-Brown and Schäfer are of great value, as, owing to the use of antiseptic precautions, and the full details and figures which illustrate the experiments, their facts are available for all inquirers. Horsley and Schäfer record several experi-

[26] See Experiments III, IV, V, VI, *Phil. Trans.*, vol. ii, 1884.

[27] Experiment V, *Phil. Trans.*, vol. ii, 1884.

[28] Experiment VII, *op cit.*

[29] Ueber die Functionen der Grosshirnrinde, 1881.

[30] *Sui Centri Psico-Sensori Corticali*, 1879.

[31] On the Sensory Localisations of the Cortex Cerebri, *Brain*, July, 1884.

[32] A Record of Experiments upon the Functions of the Cerebral Cortex, *Phil. Trans.*, vol. clxxix, 1888, B. 20.

[33] Functions of the Occipital and Temporal Lobes of the Monkey's Brain, *Phil. Trans.*, vol. clxxix, 1888, B. 30.

[34] Influence des Lésions Corticales sur la Vue, *Archives de Médecine Expérimentale*, 1889.

[35] The Centre for Vision. *Researches of the Loomis Laboratory of the Medical Department of the University of the City of New York*, No. 1, 1890.

ments on the occipital lobe on one or both sides. The following experiment (XXIV), which I give in their own words, is especially worthy of note. "The whole of the left occipital lobe was removed by an oblique incision along the parieto-occipital fissure. The piece removed included the extremity of the posterior cornu of the lateral ventricle, which was thus freely opened. No ill consequences resulted from this, however, and when on the fifth day the dressings were removed the wound was found to be completely healed. Result, no muscular paresis. The animal seems to have some disturbance of visual consciousness of the images of objects which fall upon the left side of the retinæ; for an object, such as a raisin, presented to it on the right side of the visual line, is either not noticed or its nature is not readily recognised. This condition, which was very marked at first, gradually improved, until three months after the operation it could no longer be determined." Other portions of the hemisphere, as shown in the figure, were removed, but into the results of these it is not necessary for me here to enter. The appearance of the brain is given in their figures (24A and 24B), of which one represents the under surface, and, as the authors themselves say, "the representations are mainly of interest as showing the completeness of removal of the frontal and occipital lobes, and the limits of the lesion upon the under surface of the hemisphere."[36]

Several others are recorded in which the lesions, unilateral or bilateral, trenched on the parieto-occipital fissure and region of the angular gyrus, and in none of these was hemiopia or blindness absolute or permanent. In one case (Experiment XXVI), in which both occipital lobes (external and posterior surfaces and a part of the under surface) were removed, with an interval of fourteen days between the two operations, there seemed to remain a general impairment of visual perception, without, so far as could be made out, absolute blindness in any part of the field of vision, but of this they cannot speak with certainty. On the removal of the right angular gyrus complete left hemianopia was the result, which lasted, without any sign of improvement, until the animal's death, three months afterwards. Horsley and Schäfer's experiments, therefore, in which the lesions of the occipital lobes were perhaps more extensive than any of those described by Yeo and myself—my earlier experiments excepted—show that at most the hemiopic disturbances are transient, while, in the first case referred to, there appears to have been complete removal of the occipital lobe, and yet the hemiopia was not of permanent duration. Destruction of the angular gyrus, in combination with the occipital lobe, was the only lesion which caused a permanent result. Their conclusions, as stated in their own words, are as follows:—

"Our experiments upon the occipital region, although few in number, seem to link together the conclusions arrived at by Munk, and by Ferrier and Yeo as the results of their experiments. They indicate that both the occipital lobes and angular gyri are concerned with visual perceptions in such a manner that each occipital region is connected with the corresponding lateral half of each retina, and that a part only of the cortex of the region in question is able to take on in great measure—how completely cannot be determined in animals—the functions of the whole. This is in conformity, also, with the results of Luciani. So far as the occipital lobe alone is concerned, our observations confirm the statement of Munk that the effect of this lesion is to produce a hemiopic disturbance of visual consciousness. But the imperfect vision which remains after removal of both occipital lobes (see Cases 25 and 26) suggests that the area which is concerned with visual consciousness is not confined to those lobes, as was inferred by Munk, but extends over into the angular gyrus, permanent hemiopia being produced by the subsequent removal of that convolution. It will, however, be necessary that further experiments should be undertaken, in order to determine more precisely, not only the extent, but also the relative importance of the anterior, posterior, and mesial portion of the visual area of the cortex."[37]

[36] P. 35.
[37] *Op. cit.*, p. 19.

SPRAINS.—Riches treats sprains, of however severe a character, by a quarter of an hour's daily immersion in hot water, an india-rubber bandage, and daily massage. He reports (*Jour. de Méd. Pratique*) rapid and brilliant results.

PROFESSOR KAHLER, of Vienna, who has been suffering from the effects of an attack of diphtheria, is now fully convalescent.

A CLINICAL LECTURE
ON A
CASE OF VEGETATIVE AORTIC VALVULITIS
WHICH PROVED FATAL BY EMBOLISM, ANEURYSM, AND RUPTURE OF THE LEFT PROFUNDA FEMORIS ARTERY.

Delivered at St. Bartholomew's Hospital.

By SIR DYCE DUCKWORTH, M.D., LL.D.,
Honorary Physician to H.R.H. the Prince of Wales; Physician to, and Lecturer on the Practice of Physic in, St. Bartholomew's Hospital.

GENTLEMEN,—I propose to take for the subject of my lecture today the case of J. R., who was admitted under my care in John Ward on March 8th last. Many of you will remember this patient. His symptoms at first were in no way specially noteworthy, being such as we commonly meet with in cases of heart disease due to disorganisation of the aortic valves, and that the case gave me no unusual anxiety is proved by the fact that I allowed a candidate for one of our scholarships to examine him only a few days before his death, which, as we shall find, was not only rather sudden, but due to a very uncommon cause.

As you are aware, I prefer to make my clinical lectures as practical and demonstrative as possible, but it is not always possible to bring patients into this theatre, and if I confined myself to cases which I could only show here—or, indeed, during life—you would lose some of our most instructive experiences. My senior house-physician, Dr. Willoughby, has kindly written out the clinical notes of the case for me, and they well record the leading features of it. I will read them to you.

J. R., 26, lighterman, admitted March 8th, 1890. *Present Illness* began two months ago with severe cough and pain in cardiac region. Cough and pain have remained till the present. Has "laid up" since, and has suffered from pain in head, throbbing of heart, cough, spitting of phlegm with occasionally a little blood, and short breath. No swelling of feet. *Past History.*—Rheumatic fever when 9 years old; good recovery. No other illness since. Has been lighterman since age of 13 (thirteen years' hard work). Gonorrhœa three years ago; no syphilis. Always temperate. In August, 1889, rowed 2½ miles' race on the river (great strain). *Family History.*—Father has gout; mother has morbus cordis; one brother had "rheumatics." *Present Condition.*—Strongly built man; malar capillaries injected; lips anæmic. Pulse 112, "water-hammer;" well-marked capillary pulse. Temporal arteries tortuous. Fingers clubbed. Respirations 20. Coughs and spits scanty mucus. Temperature normal. The whole body pulsates visibly. Heart: apex beat fifth space, 1 inch outside nipple line; cardiac dulness begins at third cartilage, and goes straight to apex, not across to the right; cantering action of heart at apex, no murmur; at right base loud double murmur, loudest at mid-sternum, and the diastolic murmur conducted down sternum, the systolic up the carotids. Lungs, abdomen, and extremities natural. Bowels open regularly. Urine 1020, acid, trace of albumen.

March 18th. Sudden pain in left knee yesterday, lost again in the evening. To-day slight dull pain along inner part of thigh. No œdema of leg. To inner side of femoral artery a cord felt (? thrombus internal saphena vein). Some streaks of blood coughed up.

March 19th. Increased pain last night down left thigh. Temperature 101°. Heart apex rather farther out, 1½ inch outside nipple line.

March 24th. Nightly pain in left thigh, better during the day. No œdema of leg. On auscultating femoral artery the shock of the pulse is followed by short *bruit*.

March 26th. More pain last night. The double murmur is heard more plainly at the apex, conducted there from the right base. Pulse 88. Temperature not high since the 19th.

April 2nd. Pains had continued, but had been less in severity. Heart-apex only half an inch outside nipple line. (The spleen was felt one day about this date.) Scarcely any pains in leg. No cord felt. Pulse 92, regular.